# POTENTIAL USE OF OPEN SOURCE (GOOGLE EARTH) GEOSPATIAL DATA FOR ACCURATE MAPPING - CASE STUDY OF UTP CAMPUS

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JANUARY 2009

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Dissertation submitted in partial fulfillment of
Bachelor of Engineering (Hons.)
(Civil Engineering)

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Approved by,

(Dr. Abdul Nasir Matori)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

January 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contain herein not been undertaken or done by unspecified sources or persons.

(Ahmad Taqiyuddin Obaidellah)

## ABSTRACT

This project titled '*Potential Use of Open Source (Google Earth) Geospatial Data for Accurate Mapping – Case Study of UTP Campus*' is basically a research on rectifying the UTP campus coordinate by taking references at the selected control points. The open source defined as the Google Earth Software and Geospatial Data is defined as the coordinates data. The study is based on the online mapping of the UTP campus map taken from the Google Earth. Locations of estimation at about 20 control points are decided to be the control point. These control points are randomly distributed in the UTP campus map. The control points selected should be the same control point in the Google Earth map and at the field area. For determining the coordinate from Google Earth map, a cursor is pointed at the each selected control points and the coordinate is taken for respective control points. For field work coordinate determination, the coordinates is taken by using the GPS instrument. This instrument is located at the same control points and the data reading process is done. The data collected using GPS instruments will be analyzed by using software namely as PCCDU and PINNACLE. A statistical study will be done between the survey coordinates with the Google Earth coordinates if there are differences in the coordinates comparison. These coordinates are transferred into the geosciences application software which is the ER Mapper and the ArcView GIS 3.2a for the rectification process.

This project focuses on comparing the coordinates gained through the survey process with the coordinates released from Google Earth software. The data collection of this study has been collected among the UTP campus at randomly distributed location of control points. There are 2 main objectives of this project that is to rectify coordinate of UTP campus and also to investigate the variance difference between the wrong coordinate with the actual coordinate. The aim of the project at the end of this research is to conclude whether the coordinates given by Google Earth are accurate to be use as reference coordinates.

# ACKNOWLEDGEMENT

I praise Allah for His consent in completing this dissertation. My gratefulness to the Almighty for good health and compelling strength throughout the research. First and foremost, I would like to thank Assoc Prof. Dr. Abdul Nasir Matori for the excellent supervision for which his invaluable spiritual, academic advice, stimulating suggestions, motivating comments and subtle direction of my efforts throughout learning the meaning of 'research' encouraged me to produce better research procedures and a better person as a whole.

I extend my sincere gratitude and appreciation to Mr. Abdul Basith who patiently offered me insights into the topic regarding the case study of this work. Thank you for the ideas of the project, useful advices, morale supports, help in the survey work, and most importantly being my backbone in realizing this research project. I am also thankful for the technical support from Mrs. Suhaila and Mrs Yuswati together with all supporting staff and technician at the Department of Civil Engineering, thank you for assessing me in processing the data, lending the equipments & apparatus and for friendly helpful facilitation.

A big thank you is conveyed to my comrades Muhammad Zahied Mohd Noor, Mohd Qamar Rusydi and Siti Ayunie Karsin for the time and generousity in helping me realizing and carry out the survey work, documentation of this research and also not forgetting for their friendship and laughter keeps my sanity within limit.

Last but not least, I wish to express my appreciation to the most important persons in my life. To my parents, Mr. Obaidellah Mohamad and Mrs. Wan Suriati and siblings Ahmad Taufiq, Unaizah Hanum and Izyan Najla, thank you for the precious care, support and showering love throughout these years. I strongly believed that without the help, support and lending hands by the above mention, it is impossible for me in completing this dissertation.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

The use of Global Positioning System (GPS) in positioning a location is now widespread and commonly used as device for tracking people and vehicles. GPS is potential to provide continuous positioning and timing information at any location in the world under any conditions of the weather [1]. GPS has the ability to determine the exact and precise location of a user at respective location.

Online Mapping has been a popular source to the public in getting maps via the internet source. Online mapping have been used as guidance for public to get to new places or unfamiliar locations. One example open source that uses the online mapping technology is the Google Earth. Google Earth is used as primary mapping source as it displays satellite images and integrates map of the Earth's surface.

Introduced to provide satellites views of almost at all location, Google Earth in its website mentioned "Lets you fly anywhere on Earth to view satellite imagery, maps, terrain, 3D buildings and even explore galaxies in the Sky"[2]. The ability of Google Earth constructing bird view images of locations has made Google Earth being widely use for public usage.

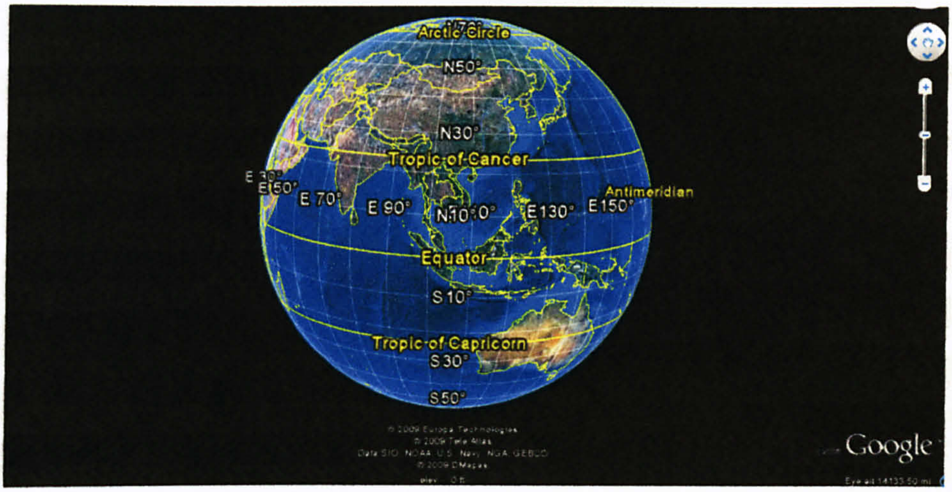

Figure 1.1. Earth Captured by Google Earth Software [3]

Known as primary mapping source, Google Earth made users able to search for locations, famous structures, determining geographical positions, finding landmarks, addresses and any places of interest entered by user. From Google Earth, all maps including the UTP map are reachable from the Google Earth Search tab. For its ability, Google Earth is chosen as comparison medium in this study.

The topic, which is '*Potential Use of Open Source (Google Earth) Geospatial Data for Accurate Mapping – Case Study of UTP campus*', focuses on comparing the coordinates gained through the survey GPS process with the coordinates released from Google Earth software. The idea is to make a research study to investigate whether the coordinates released by Google Earth are correct or having discrepancies by comparing the coordinates with the coordinates obtained by the field work study at the same control points.

In this research study, the coordinates of UTP taken from the Google Earth are unknown on its accuracy whether it has error at certain notes from its true value or vice versa. The coordinates are extracted, examined and a research study is conducted to measure the variances between the Google Earth coordinates with the coordinates from the field work. The GPS instruments will be used for the coordinate determination for the field work.

At the end of the study, a comparison will be done between the data collected (coordinates) at the field area and the data given by the Google Earth image. This is to evaluate or to assess the accuracy of coordinates from Google Earth image with those from field survey using GPS.

This research study also will develop a virtual rectified UTP campus map using the ER Mapper Software using map produced by Google Earth. This software and method is used to help increasing the geospatial accuracy of the study map. The idea is by uploading the UTP map obtained from Google Earth into the software and all the coordinates at selected control point obtained from the field work is filled into the software. The software will develop a rectified map based on the root mean square (RMS) obtained upon the input of Earthing and Northing coordinates of field work.

## 1.2 Problem Statement

Online web-mapping services such as Google Earth developed by Google provide free online web-mapping for almost all part of the world. The freeware Google Earth application relies on different providers for its aerial and satellites imagery.

A limitation of Google Earth is, it is questionable whether it provides exact precise coordinate at the exact point where the cursor is pointed. As for example, a point at one location do not have the same coordinate when measured with GPS instruments with the same location point when the cursors is pointed in the Google Earth software. Related to this study, it is believed that Google Earth provides inaccurate coordinates of UTP campus based from its satellites images.

The project uses online map from Google Earth as reference for comparison between the actual coordinate at the field area with the coordinate captured and released by Google Earth. This project takes UTP map as its study case for the rectification of the coordinate at selected control point.

## 1.3 Objectives

The objectives of this project are as follows:

1. To rectify and improve the coordinate of Universiti Teknologi PETRONAS (UTP) campus map from Google Earth using GPS data.
2. To determine quantity differences between the Google Earth coordinates and the coordinates gained by field using GPS.

## 1.4 Scope of Study

Geospatial data is the coordinates elements in the UTP map obtain from Google Earth while open source is the Google Earth software. The scope of this project is to rectify and improve the coordinate of UTP at the selected control point based on the online mapping of the UTP campus from Google Earth. The coordinate of each of the control point will be gained by using GPS instruments.

The project is to compare the collected data coordinate from GPS instruments with the coordinate given in Google Earth at the same control point. The study will be able to distinguish the imprecisely coordinate set by Google Earth with the actual coordinates.

As in the development stage, the scope is to choose the best control point to be selected for the data collection works to be done. Data collected from the GPS at the selected control point will be analyzed and executed in the software. ArcView GIS and ER Mapper are chosen as the scope of this project as it has greater capability in flexibility and customization of the online maps.

At the end of the project, the actual coordinate and the coordinate from Google Earth will be presented as comparison data. For this project, the control points are determined to have 20 different control points. There are 20 different locations decided for each different control points.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Background Knowledge / Theory

In this section, the part that will be discussed is the GPS, Google Earth and Quality Assessment of Geospatial Data.

### 2.1.1 Global Positioning System (GPS)

GPS is famously use for most activities that require high accuracy position determination. This GPS technology has become the most reliable method used as positioning and navigation in the world. As mentioned in previous section, GPS is a satellite navigation system that provides positioning and clock time.

Basically, the GPS technology was developed and designed by the U.S. Department of Defense. The purpose of this designation is to provide the military with accurate positional information [4]. This navigation system provides a civilian signal to the receiver.

The signal of a GPS is broadcast at the same time from 29 satellites. Each satellite respectively takes a 12-hour orbit. At any one time usually 8-12 satellites are visible for signaling from position on earth.

The application of GPS falls under five categories which are; location, tracking, navigation, mapping and timing [5]. Basically GPS are commonly used in fields such as surveying, mapping, transportation, agriculture, Geographical Information System (GIS), geosciences and military planning.

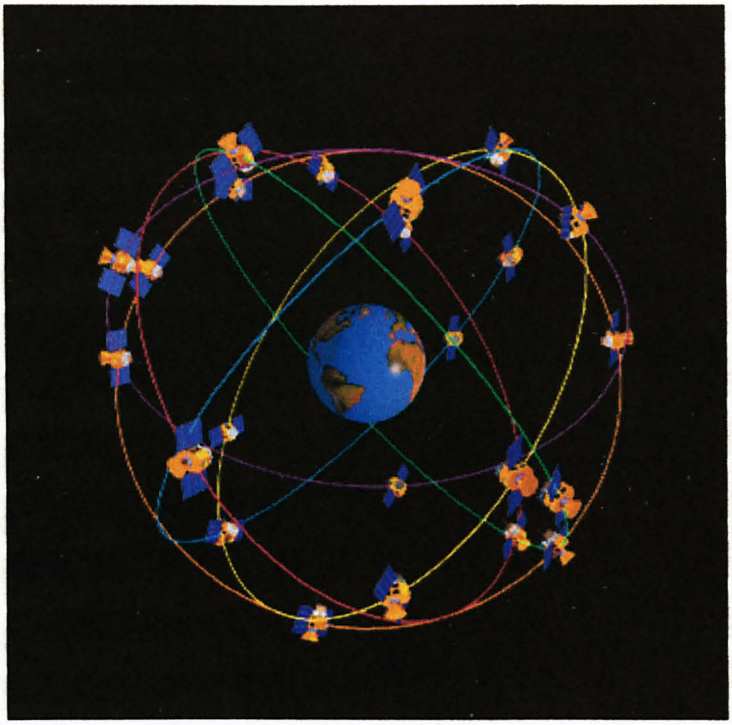

Figure 2.1. GPS Satellite Constellation Image [6]

GPS is using basic simple idea. The location of the point or receiver can be determined if the distances from a point on the Earth (at the location of the receiver) to three GPS satellites are known together with the satellite locations. This is done by applying the concept of resection [1].

For each GPS satellite around the earth, it will continuously transmit a microwave radio signal. This signal consists of 2 codes, 2 carriers and a navigation message. Upon the switching on of the GPS receiver, the receiver will absorb and pick up the microwave radio signal through the receiver antenna. This signal is captured in the receiver as raw material and will be processed using software later. Only 3 distances to 3 simultaneously retrieved satellites are needed theoretically. The GPS receiver will be located at the intersection of spheres which the radius of the sphere is the distance between the receiver and the satellite. The presence of the fourth satellite would be needed in counting the receiver clock offset.

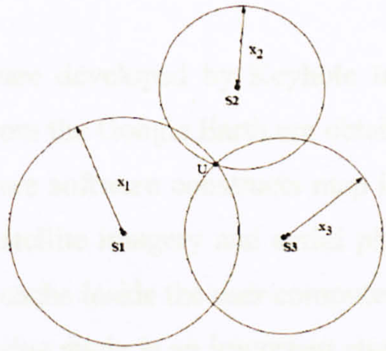


Figure 2.2. Idea of GPS positioning

GPS signals consist of the ranging signals that is used to measure the distance from the receiver to the satellite and navigation messages. These navigation messages include the ephemeris data. This ephemeris data will be used to calculate the position of the satellite in orbit, its constellation status and also information with regard to the time.

There are two types of GPS signals which are the P-Code (Precise Code) and C-Code (Civilian Code). The P-Code has an extreme length of codes compare to the C-Code. This extreme length of P-Code increases its correlation gain and also eliminates range ambiguity. The differences between the P-Code and the C-Code are summarized as Table 2.1 beside :

Table 2.1. Comparison between P-Code Signal and C-Code Signal

| P-Code | C-Code |
|---|---|
| Very Precise | Less Precise |
| Signal Not Degraded | Signal Can Be Degraded (degraded to SA) |
| Only available to the military and some selected public officials | Available to all public GPS receivers (Garmin GPS Map76) |

### 2.1.2 Google Earth

Google Earth is a software developed by Keyhole Inc, a company under the Google Corporate. The images from the Google Earth are obtained by satellite imagery and aerial photography. This freeware software constructs map images by downloading files from its remote server. This satellite imagery and aerial photograph are stored in the remote server and transferred as cache inside the user computer upon the first loading of the files. In this study, remote sensing study is an important study in giving introduction to digital image processing and its application. Remote sensing can be defined as the acquisition and recording of information about an object without being in direct contact with that object [7].

Google Earth with its satellite imagery mostly is using the Landsat high resolution data. Landsat is a combination word of Land and Satellite. Google Earth is taking the Landsat 7 ETM Satellite Remote Sensing Data. This Landsat 7 captured up to 30 meters resolution. From a website of NASA Landsat mentioned that the highest-resolution data available in Google Earth is Landsat 7 ETM+ pan-sharpened data (15 m) [8].

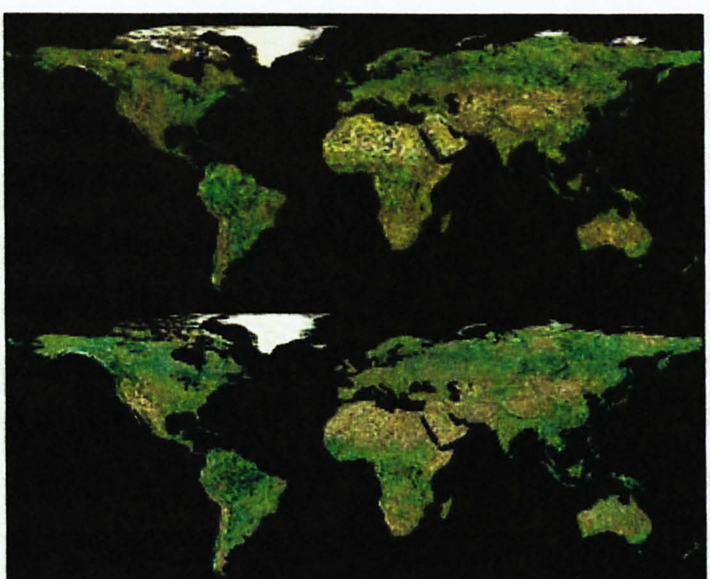

Figure 2.3. Landsat 7 image mosaics used in Google Earth, NaturalVue (top), TruEarth (bottom) [8]

For certain high resolution image in Google Earth, Google Earth is taking the QuickBird Satellite Remote Sensing Data. This type of satellite remote sensing data is able to capture 0.6-2.4 meters resolution. At this resolution, details such as buildings, structures and roads are visible to user.

One of the advantages of Google Earth is the ability of zooming. One can explore more details to reveal the maps. Unlike with traditional remote sensing images where it is easy not to see the wood for the trees, this zoom facility allows small-scale topographic and geological features to be instantly placed in a broader regional context [9].

In this research study, Google Earth is chosen as the medium to provide the satellite imagery of UTP campus. For this project, an online map of UTP campus covering all the campus area with coordinates is needed. Google Earth is important to this research study as it will provide the eye bird view of UTP from the satellite image. Google Earth also significantly provides coordinates whichever the cursor is placed.

The coordinate system of Google Earth is using WGS 84 (World Geodetic System of 1984) as its geodetic reference system. The origin of this WGS 84 is the Earth centre of mass. The developer of Google Earth chooses to use WGS 84 as the same coordinate system used by GPS technology for easier reference.

### 2.1.3 Quality Assessment of Spatial Data

Quality assessment is the control quality of certain parameters or in this case is the spatial data. The spatial data defined in this study is the elements of coordinates obtained from the Google Earth and from the field study. The coordinates of the Google Earth maps are assessed on their accuracy by comparing them with fixed (assumed) coordinate obtained from GPS survey. The spatial data are compared with the data obtained by field work and assessed through analysis. This analysis is further discussed in *Chapter 4: Results and Discussion.*

## 2.2 Importance of Research

This research is important as it give benefits to UTP by providing a corrected/rectified image from Google Earth image of that particular area. This actual coordinate will help UTP :

i. On planning construction for further renovation.
ii. Smoothing the process of surveying.
iii. To have a prove by comparison that the coordinate from Google Earth at the same control point is not accurate as the actual coordinate

A proper study on comparing the Google Earth coordinates of UTP campus and GPS coordinate has not been conducted. Thus, this study is important in coming out with analysis whether the coordinate obtained via Google Earth is accurate with the GPS determination coordinate from field world or vice versa.

## 2.3 Previous Work

According to Earth Ranger Adam [10], "Google Earth are made for entertainment purpose only and reminded that Google Earth should not be used for any navigational or any other purpose requiring accuracy. This is because Google acquires imagery from various different sources with many different file formats, projection and spectral characteristic. All of this imagery sources then fused into a single globe database with proprietary format. Thus, it is possible that the imagery to have offset from the actual field or ground in some areas."

According to Cimexus [11], Cimexus noticed that Google Earth does not provide up-to-date imagery pictures as the Google Maps provides. This meant that there are discrepancies occurred between the Google Earth and Google Maps services.

According to Dr. Jayanta Kumar Ghosh, et al in [12], in most engineering project that refers to survey of an area, it is crucial to set out correct control points during mapping. GPS instruments are used as important tool in finding of control point accurately, quickly and economically.

In the author research, coordinates transformation matrix should be apply with the local coordinate system. This local coordinate system was transferred from the coordinated obtained by the GPS instruments.

Findings from Dr. Jayanta Kumar Ghosh demonstrated that transformation of the observed GPS coordinates to its respective local coordinated would refer to three orientations known as North, East and Vertically up direction. This establishes the control point values for the given coordinate.

As stated by Mitoshi Moriya and Sota Shimano in [13], a way is needed to update the large scale map. This establishment should be using a REAL TIME GIS and its collaboration. REAL TIME GIS is a technology that updates maps using GPS and cellular phones. In order to pursue this, a transformation of coordinates is needed. Mitoshi mentioned that large scale map did not have satisfactory accuracy due to the old geodetic system. Thus, to obtained accuracy of the map, a system which transforms the old geodetic system to a new geodetic system is needed. In his findings, he noticed that method of making control point was not finished and completed as it is difficult to have coordinates on maps and to search the exact point at the field area. As a replacement of this, the author uses town planning group data and cadastral data for coordinate transformation. Author increased and improved the accuracy by overlaying and transforming high-accuracy regional parameter using affine transformation. Transformed method are used in his findings. As the conclusion for the writings, the author suggested and recommends the local government to introduce and use the system of REAL TIME GIS and Remote Sensing Imageries for any work related to the field. The differences between the author writings with the research topic is that the author improve the map renewal technique using method of transformation by laying the high-accuracy regional parameter using the collaboration of GPS, GIS and Remote Sensing while this research topic improve accurate mapping by comparing two coordinates which are obtained visually from open source software and obtained by field work activity at same control point.

You Hongjian, et al in [14] discussed about method to rectify scanning image based on Global Positioning System (GPS) and Inertial Navigation System (INS). In the findings, the positions of pixels within the same scanning line are calculated and the same pixels are used as Ground Control Points to rectify the scanning line. In the preliminary stage of the research, the author stated that airbone infrared image is often distorted because of the altitude and position change of the airplanes. This means that images captured by planes are easily distorted due to the different height, elevation and altitude of the camera. Thus, several control points should be used to rectify the distorted images. In his findings, the author discussed a new method to be used is to rectify scanning image fast based on GPS and INS. The different method used compare to the research study is by the pixel adjustments that will be used as control point to rectify the images. The rectification processes are based on the GPS and INS systems. For initial study, a calculation of pixels from the images are done in the scanning coordinate system and in the local geographic coordinate system based on the GPS and INS. Later, the image is rectified based on the coordinates of the pixel. Once again, different method of improving and rectifying images introduced by the author which is working with the pixels compared to the research study which compare two coordinates from different source at the same control point.

According to Youb Lee and Woo Han in [15], the objective of the authors writing are to analyze the advanced earthmoving system using GPS and compare the work procedure and property of both the traditional and the advanced earthmoving system which they believe the GPS implementation is beneficial for geospatial construction data collection. The idea of the findings is to collect the geospatial construction data via GPS. In the writings, the authors mentioned that by using their findings, it can help improving productivity by the simplification of procedure.

Based on Daniel Sullivan and Alison Brown in [16], the author introduced and described the implementation of a GPS/Inertial integrated navigation system (GI-Eye) that georeference images captured by digital camera without requiring control points. In their findings, the authors mentioned that the GI-Eye system able to georeference features extracted from airborne imagery to meter-level accuracy. The author has demonstrated and present flight test result of the GI-Eye which shows the precision geolocation performance and the ability coming out with autonomous image rectification and georegistration without requiring any ground control points. The advantages of this findings as mentioned by the authors in their writings stressed that the result is useful as it indicates the ability to ortho-rectify airborne imagery with no image tie-points and no image manipulation in coming out with the rectified results. By the data collection process, the image rectification results indicate that total position error is below one meter and attitude error below one mrad absolute. This position error is later reduced to centimeters using GPS RTK solution.

Zaul A Zandbergen from University of New Mexico in [17] mentioned in his findings classify the distribution of the positional error in four types of spatial data which are GPS locations, street geocoding, TIGER roads and LIDAR elevation data. The author in the writings makes a research on the positional error of each of the spatial data. As indicated, the positional error in GPS locations is approximated with Ralyeigh distribution, positional error in street geocoding and TIGER roads are approximated with log-normal distribution and last, positional error in LIDAR elevation data is approximated with a normal distribution of the original vertical error values. However, the disadvantages of the findings are, for all four data types considered, these solutions are in approximation and it is observed that there is some evidence of non-stationary behavior resulting in lack of normality in all four data classification set. In his research study, the author emphasizes the study of the positional error at the four data types. By referring to samples from other people research, the author study on the characterization of the error for the data sets.

Findings from David Potere on [18] mentioned that the method to increase the scientific utility of Google Earth's High Resolution Imagery archive is addressing horizontal positional accuracy (georegistration) by comparing Google Earth image with Landsat GeoCover of 436 control points located in 109 cities worldwide. David Potere mentioned in his findings that Landsat GeoCover is an orthorectified product with its known positional accuracy (absolute) is less than 50 meters root mean squared error (RMSE). Moreover, 436 Google Earth control point that relative to Landsat GeoCover have a positional accuracy of 39.7 meters RMSE. His findings indicate that high resolution imagery of Google Earth has a horizontal positional accuracy that is sufficient to assess moderate-resolution remote sensing product at the peri-urban areas of the world.

**2.4 Discussion on Forums**

There are many discussions by the Google Earth users via the online forum to discuss the accuracy and discrepancies of the Google Earth data.

(i) Google Groups Discussion [19]

Topic : Latitude/Longitude of Google Earth and GPS not the same

From the Google Groups Discussion with the topic mentioned above a user by the nick of RoystonB mentioned that the latitude and longitude given by the Google Earth at the bottom left of the software shows a completely different latitude and longitude when he compared it with the latitude and longitude given by the GPS device.

(ii) CADTutor Discussion Forum [20]

Topic : Google Earth Coordinates Don't Match Up

From the CADTutor Forum, below are the thread posted by *jeffj*:

"I am attempting to map some lat long coordinates of several polygon centroids that I have created from a CAD map into Google Earth. However, after inputting a lat long coordintate into Google Earth, it is several metres off. For example, if the centroid is supposed to be of a building, on Google Earth it will show up on the street next to the building instead of on the centroid of the building." [20]

The user was attempting to project coordinates (of polygon centroids) into Google Earth from a CAD map. The result shows the coordinates are several metres off after the projection. The centroid is not exactly on the place where it should be.

(iii)Enhanced Vector Shorelines (EVS) Islands Discussion [21]

Topic : Comparison – Google Earth Georectification vs Landsat ETM+ Georectification. Who is Right?

A teacher by the nick of Mr Minton from San Diego made a comparison between Google Earth Georectification and Landsat ETM+ Georectification by taking Isla Blanquilla as the test location. When he loaded the ISS georectified base image of Isla Blanquilla on top of the Landsat image, the location is right and precise on the image. However, when he creates and overlay of the ISS image in Google Earth, the image doesn't fit well.

The next test is by recording the latitude and longitude location of 3 relative control points in the Google Earth and in Global Mapper's Landsat display. Both shows the same image of Isla Blanquilla. However after recording latitude and longitude for each point and determining the differences, he stated that 'someone is off anywhere between 2-meters and up to 63-meters for this single island'. Thus he concluded that a misplotted of the island occurred whether by the Google Earth or Landsat ETM+.

Replying to his thread;

A user by the nick of *perrygeo* posted :

> ''I wouldn't trust Google imagery's positional accuracy for one second! I've found dozens of locations where their georectification doesn't match any number of other sources (all of which agree with each other.) It's truly horrible in some places where their imagery is off by hundreds of feet.'' [21]

*Perrygeo* mentioned that when dealing with accuracy he wouldn't trust the Google Earth image as he found his georectification does not meet and match with the source from the Google Earth image. Some of his research locations images are having off by hundreds of feet.

# CHAPTER 3

# METHODOLOGY

## 3.1 Project Methodology

The Figure 3.1 below shows the project flowchart for this project:-

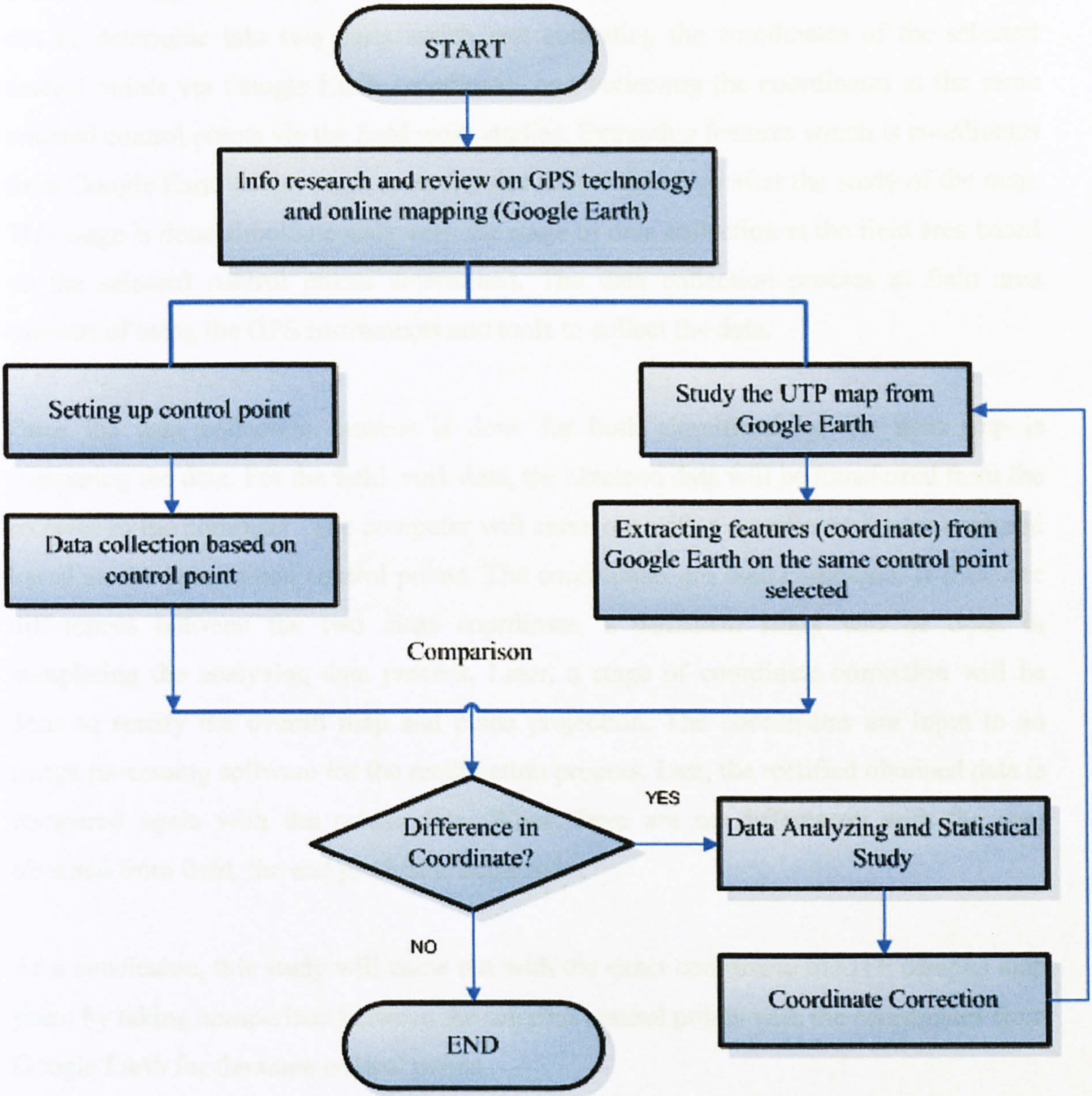


Figure 3.1. Project Flowchart

### 3.2 Introduction

The project starts on the info search and review of GPS technology and Online Mapping from Google Earth. The map of UTP campus is captured using the Google Earth Open Source software. Next stage is classified into two which is the study of the captured UTP campus map and Setting Up Control Points on the map captured. For the study of the captured UTP campus map, the purpose is to get clear view, understanding and information regard the scope of the study. Next stage is the data collecting process than can be determine into two parts which are; collecting the coordinates of the selected control points via Google Earth coordinates and collecting the coordinates at the same selected control points via the field work studies. Extracting features which is coordinates from Google Earth of the same control point follow the stage after the study of the map. This stage is done simultaneously with the stage of data collection at the field area based on the selected control points determined. The data collection process at field area consists of using the GPS instruments and tools to collect the data.

Once the data collection process is done for both classifications, the next step is comparing the data. For the field work data, the obtained data will be transferred from the receiver to the computer. The computer will came out with a set of coordinates captured based on the determined control points. The coordinates are then compared. If there are differences between the two class coordinate, a statistical study will be done in completing the analyzing data process. Later, a stage of coordinate correction will be done to rectify the overall map and plane projection. The coordinates are input to an image processing software for the rectification process. Last, the rectified obtained data is compared again with the actual data. When there are no differences with the data obtained from field, the end product is achieved.

As a conclusion, this study will came out with the exact coordinate of UTP campus map plane by taking comparison between the selected control points with the coordinates from Google Earth for the same control points.

## 3.3 Area of Study

The area of study covers the UTP campus. The map of the UTP campus obtained from the Google Earth gridded with A to J on X-axis and 1-7 on Y-axis. The figure of the topography UTP campus map is as below:

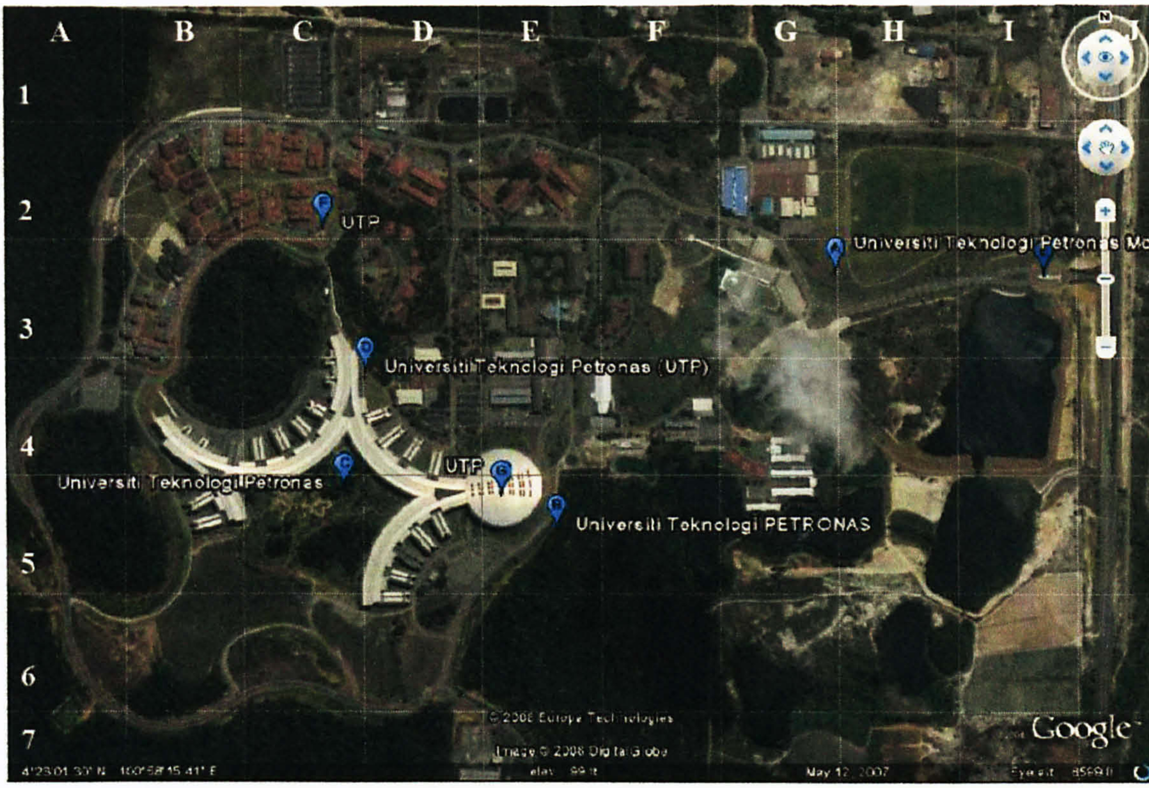


Figure 3.2. Topography Map of UTP Campus

Universiti Teknologi Petronas (UTP) campus is located at Tronoh which is the west part of Perak. The UTP campus is about 25 kilometers from the main Perak city, Ipoh. The total study area is estimated about 400 ha which is equivalent to 934 acres. The UTP campus area lies between the latitude 4° 22' 16.91637'' N to 4° 23' 25.7225" N and longitude 100° 57 28.18015" E to 100° 58' 34.20999" E.

### 3.4 Analyzing Maps from Google Earth

UTP campus map are captured from the Google Earth. Different elevations of UTP campus maps are captured for the purpose of studying and analyzing the maps. The considerations of choosing the best map that are taken into account are as below:

- The map should cover all plan view of UTP campus.
- The map should be in the format of plan view.
- All control points selected can be lay on the chosen map.

The map that has been chosen to be the research map is as Table 3.1:

Table 3.1. Google Earth Eye Altitude for respective map

| Map | Google Earth Eye Altitude |
|---|---|
| Map 1 (Prelim Study) | 6599 ft (2011 m) |
| Map 2 (Sample test study map) | 1152 ft (351 m) |
| Map 3 (Study) | 7177 ft (2187 m) |

### 3.5 Control Points

Control points that are also refer as reference points acts as fixed points for the data to be taken from time to time.

In this study, test data sets will be focusing on 20 control points around the UTP campus. The chosen control points are chose by randomly distributed method. The considerations that are taken into account when choosing the control points are:

- The location of the control points should be at an open space. This is to prevent any obstacle that can destruct the signal of the satellite and the receiver.

- The location of control points should be equally distributed around the UTP campus area with the accessibility of the researcher.
- The location of the control points should be easy to recognize from the image of the Google Earth software for the purpose of data collection via Google Earth.

The specific control points are as Table 3.2 below:

Table 3.2. Grid coordinates for each of control points

| Control Points | Grid** (Refer to Figure 3.2) |
|---|---|
| 1 | *C5* |
| 2 | *C6* |
| 3 | *A6* |
| 4 | *A4* |
| 5 | *F2* |
| 6 | *E4* |
| 7 | *E3* |
| 8 | *D3* |
| 9 | *C1* |
| 10 | *A2* |
| 11 | *D1* |
| 12 | *G2* |
| 13 | *G2* |
| 14 | *H2* |
| 15 | *G5* |
| 16 | *I2* |
| 17 | *I3* |
| 18 | *I4* |
| 19 | *I4* |
| 20 | *H4* |

### 3.6 Equipment Set up

Equipment Set up is important before the field work to be done or any data to be collect. The equipment to be used is the GPS instruments (Model No : *IHPR 005 72/75/84/88*). Before using and setting up, this instruments need to be charged for estimately about 4-8 hours duration. Once it is fully charged, the instruments are able to last up till 6 hours. Once the 6 hours usage time is completed, user is able to continue the data collection process using the external battery that can only last about 4 hours estimate time.

For this research the apparatus that will be used are as below:

(a) Materials

- Nails
- Hammer
- Spray
- Field Bag
- Writing Sets

(b) Equipments

- 4 sets of Tripod
- Measuring Tape
- 4 set of GPS Instruments
- Computer and Data Cable
- Walkie Talkies
- Software; (Mapping, Topcon Link Software, ER Mapper, Arcview)

In setting up the equipment, the procedure below should be follow :

i. Hammer a nail on a selected control point

ii. A tripod is set up exactly above the nail

iii. The bubble on the tripod is made sure on the centre of the circle to level the tripod.

iv. The GPS receiver is installed on the tripod

v. The receiver setting, GPS status, mode of positioning is check to be in correct and standby position.

**3.7 Data Collection**

Once the control points or reference points is selected and determined (for this research study - 20 control points is selected), the next process it to collect the data which is the coordinates of the determined control point.

Data collection at the field area is based on the readings of the GPS instruments at the selected control points. For all the control points, the coordinate of each control point is taken using the GPS instruments.

A GPS instrument is set up at a determined control point location. One control point is chosen as the base control point and as reference for the remaining control points. As mentioned before, for each control point, a nail is used as a representative of the control points.

Firstly, a control point is set as a base point while others are set as a normal point. For the base control point, the GPS receiver and tripod is set up there and will not be moved and should be static for the entire of the data collection process. The balance of the GPS receivers are set up at different control points and will be move out to another control points with the time gap of 15 minutes for each of the control point. This means that, after a 15 minutes period, the GPS receiver is move to another control point and stays for the same period of 15 minutes. These steps are repeated until the receiver collect data for all of the control points determined.

For the data collection via the Google Earth open source software, a cursor is place at the same control point with the field control point. The latitude and longitude of the reading is taken from the software upon the pointing of the cursor at the selected control points. The Google Earth software will gives the reading in the Northing and Easting reading at the bottom left corner of the layout. This step is repeated for all of the control points provided that the cursor is placed exactly on the exact location of the control points. This coordinate will act as a comparison coordinate with the actual coordinate taken at the field work later. Besides giving the reading of the latitude and longitude at the bottom left corner, Google Earth also gives the reading of Eye altitude (elevation of the user altitude) at the bottom right corner of the layout. Refer Figure 3.3.

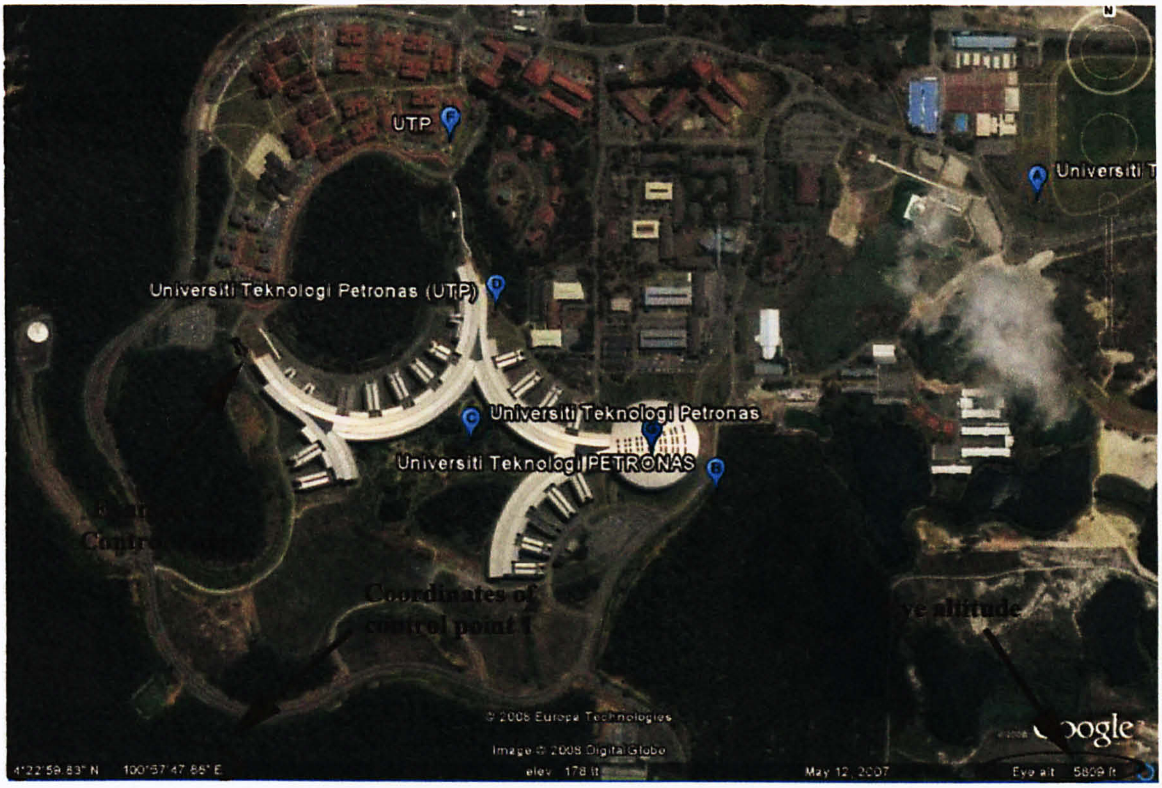


Figure 3.3. Coordinates of control point are shown at bottom left corner while Eye Altitude is shown at bottom right corner.

## 3.8 Data Processing

A data processing is a process on analyzing the data obtained from the field work. The data that is obtained from the receiver for the field work are the raw data. A software is needed to translate the raw data to a readable data. A software which is called PCCDU is used to transfer the data collected by the GPS instruments into the computer. GPS records will be process using PINNACLE software. This software integrates and converts the raw data from the receiver to coordinates form.

Coordinates will be computed into the ER Mapper for the Geocoding Wizard analysis. Geocoding is a process for matching latitude and longitude with a spot on a computerize map [22]. This Geocoding Wizard consists of 5 steps that are listed as below:

i. Step 1 : Start (Geocoding Type)
ii. Step 2 : Polynomial Setup (Method Selection)
iii. Step 3 : GCP Setup
iv. Step 4 : GCP Edit
v. Step 5 : Recitfy


Figure 3.4. Process Flow of Geocoding Wizard of ER Mapper Software

There are 5 stages in the Geocoding Wizard which are Start, Polynomial Setup, Ground Control Point (GCP) Setup, GCP Edit and Recify.

In ER Mapper software, for the Start stage, a Polynomial geocoding type is chosen as the Geocoding Type as this geocoding type reduce distortion that effect entire image. This Polynomial Geocoding type is often used to correct satellite images.

In the Polynomial Setup, there are 3 main methods upon doing the rectification using the ER Mapper software which are linear, quadratic and cubic. Linear requires at least 3 ground control points, while quadratic requires 6 ground control points and cubic requires at least 10 ground control points. Among this method, cubic is the most accurate method as it requires more control points compared to others. Cubic gives the smoothest fit, while linear provides a simpler or a sharp fit.

For the stage of Ground Control Point (GCP) Setup, the Output Coordinate Space for geodetic datum, geodetic projection and coordinate type are chosen as below:

Table 3.3. Output Coordinate Space

| | |
|---|---|
| Geodetic Datum | WGS 84 |
| Geodetic Projection | NUTM 47 |
| Coordinate Type | North Easting |

GCP Edit is where user input the coordinate of the control points in the wizard. Coordinates in Easting and Northing gained from the GPS tools are entered into the wizard. The software will came out with coordinate X and Y in the screen for each of the ground control points. Root Mean Square (RMS) will be produced by the software. The average RMS will indicate whether the ground control point is accurate or not accurate. To improve the overall accuracy of the lay images, the RMS errors for each point should be lower than the pixel size determined by the software.

A statistic study of the data will be done to discuss on several attributes between the actual coordinate gained and the coordinate from the Google Earth. This will be further discussed on *Chapter 4 : Result and Discussion* part later.

### 3.9 Tools

As for working for this research, the geosciences application software, which are ER Mapper (version 6.2) and ArcView GIS (version 3.2a) will be used and utilized along the project outcome.

The ER Mapper (version 6.2) is an image processing software for remote sensing earth science applications. This software allow user to work on large Earth data sets. Users are given the capability to manipulate complex data and image processing operations across multiple layers. Users also able to treat the data as a real data set.

Added functionalities such as modifying and customizing the standard algorithm in the ER Mapper library as well as creating new algorithms are also available for the users to change according to their specification. Based on the Earth Resources Mapping website, ER Mapper also has the ability to automatically merge, clip, sub-sample, super-sample, rescale and mosaic multiple data sets as well as providing image warping functionality for more focused image resolution [23].


Figure 3.5. Snapshot of the ER Mapper program software

ArcView GIS is a desktop mapping software and GIS application that works as a geographic analysis to the user. Arcview GIS is a program with immense capability and a wealth of features [24]. This software allow user to work with the spatial data, analysis it and allow user to view it. In this research ArcView GIS is used to extract features from the rectified map. ArcView able to work with multiple layers and layouts.

# CHAPTER 4

# RESULTS AND DISCUSSION

This part will discuss on the results obtained by the field work and Google Earth study by taking the coordinates as the geospatial data as data for the study.

## 4.1 Sample Study

A sample study has been conducted before a real field study has been done. This sample study covers a small part of the UTP map area which is around the Main Hall location (Refer Appendix for Control Point Layout Drawing). The purpose of this sample study is:

a) To learn and familiarize with the GPS tools and equipments such as the functions and setting up the tools.
b) To learn the process of gathering data at the selected control point
c) To learn extracting and analyzing the data from the receiver.
d) To learn the flow of the project and to follow the methodology on small field study.

## 4.2 The Study

The study that has been conducted lies on the UTP campus area (Refer Appendix for Control Point Layout and Study Map) that is obtained by an imagery satellite image from the open source, Google Earth. The study is done on:

| | | |
|---|---|---|
| Date | : | $28^{th}$ November 2008 |
| Time | : | 9 am – 7 pm (local time) |
| Venue | : | UTP Campus Area |

Below is the summary table of the sample test study conducted:

Table 4.1.Summary Table of Study

| Item Name | Item Value |
|---|---|
| **Subnet** | |
| Name | Session |
| Number of Points | 20 |
| Number of Unknowns | 60 |
| Degree of Freedom | 27 |
| Declared Adjusted Type | with fixed and weighted points |
| Performed Adjusted Type | with inner constraints |
| Aposteriori Standard Error of Unit Weight | 0.839 |
| Adjustment Date and Time | 28 November 2008, 09:10:53 (Greenwich Time) |

There are 20 Control Points captured during the sample test study. Each Ground Control Points will have 3 parameters which are x, y and z. Thus it will resulting 60 unknown numbers as stated in table above.

**4.3 Results**

The purpose of the study is to obtain the coordinates in latitude and longitude for each control point selected. From the study, the results obtained are as below:

Table 4.2 Coordinates Obtained for Test Study Control Points

| Point | | Coordinates | | | | Height (m) |
|---|---|---|---|---|---|---|
| No | Name | Latitude | Longitude | Northing (m) | Easting (m) | |
| 1 | Point 1 | 4° 22'53.45132" N | 100° 57'56.26621" E | 484584.38317 | 718132.95380 | 23.3024 |
| 2 | Point 2 | 4° 22'42.09703" N | 100° 58'00.89135" E | 484235.92415 | 718276.49909 | 31.7466 |
| 3 | Point 3 | 4° 22'48.31201" N | 100° 57'42.53824" E | 484425.38174 | 717710.02371 | 39.4431 |
| 4 | Point 4 | 4° 23'00.91256" N | 100° 57'44.32752" E | 484812.64686 | 717764.18838 | 46.6125 |
| 5 | Point 5 | 4° 23'13.13076" N | 100° 58'19.58847" E | 485190.87757 | 718850.57632 | 20.8723 |
| 6 | Point 6 | 4° 23'00.01518" N | 100° 58'16.31596" E | 484787.66596 | 718750.71942 | 24.1477 |
| 7 | Point 7 | 4° 23'10.17232" N | 100° 58'09.99540" E | 485099.20801 | 718554.98524 | 29.7622 |
| 8 | Point 8 | 4° 23'09.16408" N | 100° 58'01.74557" E | 485067.56337 | 718300.65934 | 45.9108 |
| 9 | Point 9 | 4° 23'20.05434" N | 100° 57'59.84068" E | 485401.98627 | 718241.03774 | 25.4407 |
| 10 | Point 10 | 4° 23'12.36167" N | 100° 57'45.67507" E | 485164.50135 | 717804.82235 | 43.4025 |
| 11 | Point 11 | 4° 23'19.52831" N | 100° 58'06.54364" E | 485386.36876 | 718447.78439 | 28.1317 |
| 12 | Point 12 | 4° 23'17.22324" N | 100° 58'26.46109" E | 485317.16823 | 719062.18239 | 22.2736 |
| 13 | Point 13 | 4° 23'11.56439" N | 100° 58'29.18590" E | 485143.53446 | 719146.66843 | 11.3449 |
| 14 | Point 14 | 4° 23'15.41207" N | 100° 58'33.10118" E | 485262.06438 | 719267.09581 | 30.4750 |
| 15 | Point 15 | 4° 22'54.66923" N | 100° 58'27.36618" E | 484624.32093 | 719091.91956 | 24.8039 |
| 16 | Point 16 | 4° 23'16.15222" N | 100° 58'45.33811" E | 485285.80063 | 719644.39825 | 24.9866 |
| 17 | Point 17 | 4° 23'08.79274" N | 100° 58'44.83465" E | 485059.65573 | 719629.47014 | 18.1858 |
| 18 | Point 18 | 4° 23'02.08622" N | 100° 58'46.71277" E | 484853.76545 | 719687.93221 | 17.0331 |
| 19 | Point 19 | 4° 22'55.93881" N | 100° 58'41.99122" E | 484664.51522 | 719542.82679 | 21.9708 |
| 20 | Point 20 | 4° 22'56.55227" N | 100° 58'36.28524" E | 484682.89801 | 719366.81502 | 16.8022 |

Figure below shows the control point layout developed by the PINACCLE Software. As shown there are 20 control points which the control point no 1 is the base control point. All of the points are connecting with base control point. The Y-axis of the graph is the

Northing axis while the X-axis is the Easting axis. (Refer Appendix for Imagery Image of UTP Map with Satellite Network)

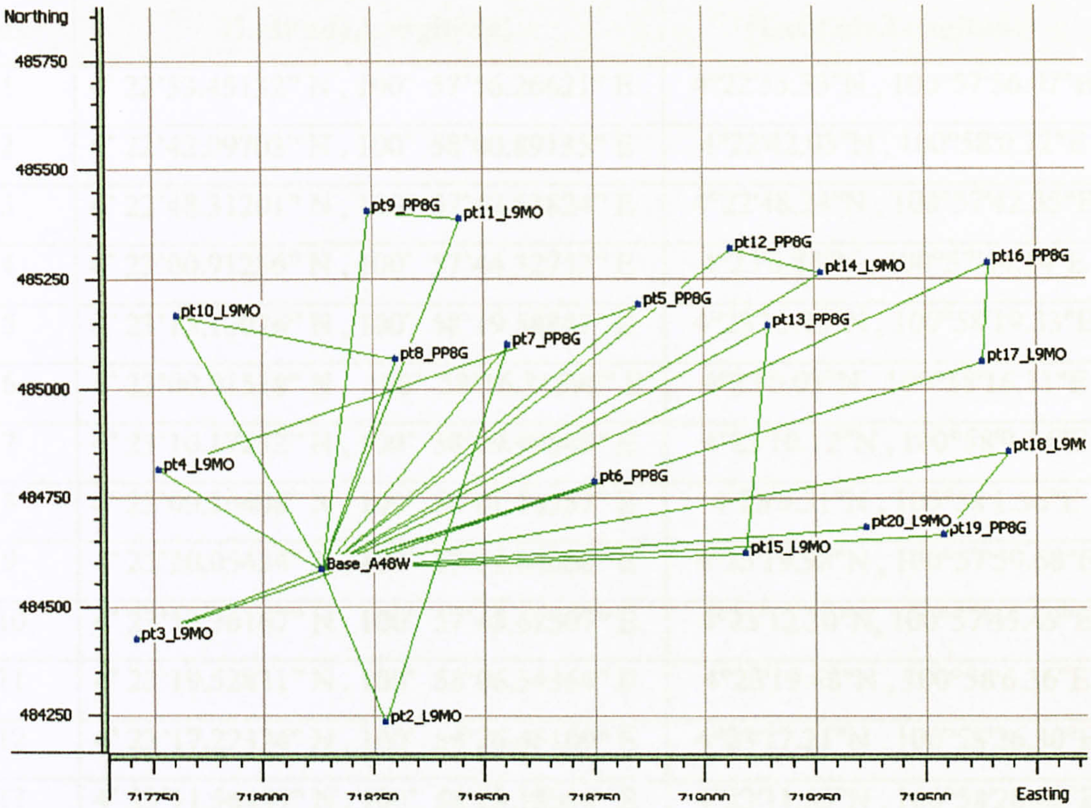


Figure 4.1. Network-Layout of Control Points produced by Pinnacle

Based on the study, there are 20 coordinates obtained from the field work. At the same point, coordinates at same control points are taken from the Google Earth software for the comparison and rectification purpose. Stated in Table 4.3 is the comparison of those geospatial data.

Table 4.3. Comparison of Geospatial Data (coordinates) between the field work study and the Google Earth study

| Control Point | Coordinates (Field Work) (Latitude,Longitude) | Coordinates (Google Earth) (Latitude,Longitude) |
|---|---|---|
| 1 | 4° 22'53.45132" N , 100° 57'56.26621" E | 4°22'53.33"N , 100°57'56.07"E |
| 2 | 4° 22'42.09703" N , 100° 58'00.89135" E | 4°22'42.03"N , 100°58'0.72"E |
| 3 | 4° 22'48.31201" N , 100° 57'42.53824" E | 4°22'48.24"N , 100°57'42.35"E |
| 4 | 4° 23'00.91256" N , 100° 57'44.32752" E | 4°23'0.84"N , 100°57'44.14"E |
| 5 | 4° 23'13.13076" N , 100° 58'19.58847" E | 4°23'13.13"N , 100°58'19.33"E |
| 6 | 4° 23'00.01518" N , 100° 58'16.31596" E | 4°23'0.03"N , 100°58'16.11"E |
| 7 | 4° 23'10.17232" N , 100° 58'09.99540" E | 4°23'10.12"N , 100°58'9.74"E |
| 8 | 4° 23'09.16408" N , 100° 58'01.74557" E | 4°23'9.31"N , 100°58'1.56"E |
| 9 | 4° 23'20.05434" N , 100° 57'59.84068" E | 4°23'19.98"N , 100°57'59.68"E |
| 10 | 4° 23'12.36167" N , 100° 57'45.67507" E | 4°23'12.30"N, 100°57'45.49"E |
| 11 | 4° 23'19.52831" N , 100° 58'06.54364" E | 4°23'19.48"N , 100°58'6.36"E |
| 12 | 4° 23'17.22324" N , 100° 58'26.46109" E | 4°23'17.21"N , 100°58'26.30"E |
| 13 | 4° 23'11.56439" N , 100° 58'29.18590" E | 4°23'11.55"N , 100°58'28.82"E |
| 14 | 4° 23'15.41207" N , 100° 58'33.10118" E | 4°23'15.40"N , 100°58'32.75"E |
| 15 | 4° 22'54.66923" N , 100° 58'27.36618" E | 4°22'54.65"N , 100°58'27.35"E |
| 16 | 4° 23'16.15222" N , 100° 58'45.33811" E | 4°23'16.16"N , 100°58'45.15"E |
| 17 | 4° 23'08.79274" N , 100° 58'44.83465" E | 4°23'8.79"N , 100°58'44.63"E |
| 18 | 4° 23'02.08622" N , 100° 58'46.71277" E | 4°23'2.10"N , 100°58'46.52"E |
| 19 | 4° 22'55.93881" N , 100° 58'41.99122" E | 4°22'55.93"N , 100°58'41.70"E |
| 20 | 4° 22'56.55227" N , 100° 58'36.28524" E | 4°22'56.59"N , 100°58'36.05"E |

Table 4.4 shows the differences in latitude and longitude as well as in meters for every 20 control points. The differences are between the coordinate of the exact location gained from the field work activity with the coordinates at the same point released by Google Earth.

Table 4.4. Differences in Latitude, Longitude and meters.

| Control Point | Differences in Latitude and Longitude | Differences in meters (m) |
|---|---|---|
| 1 | 0°00'0.2306" | 7.1 |
| 2 | 0°00'0.1841" | 5.67 |
| 3 | 0°00'0.1928" | 5.94 |
| 4 | 0°00'0.2006" | 6.18 |
| 5 | 0°00'0.2585" | 7.96 |
| 6 | 0°00'0.2064" | 6.36 |
| 7 | 0°00'0.2602" | 8.01 |
| 8 | 0°00'0.2345" | 7.22 |
| 9 | 0°00'0.4080" | 12.57 |
| 10 | 0°00'0.2047" | 6.30 |
| 11 | 0°00'0.1897" | 5.84 |
| 12 | 0°00'0.1616" | 4.98 |
| 13 | 0°00'0.3608" | 11.11 |
| 14 | 0°00'0.3513" | 10.82 |
| 15 | 0°00'0.0251" | 0.77 |
| 16 | 0°00'0.1872" | 5.77 |
| 17 | 0°00'0.2047" | 6.3 |
| 18 | 0°00'0.1934" | 5.96 |
| 19 | 0°00'0.2913" | 8.97 |
| 20 | 0°00'0.2382" | 7.33 |

From the result, the study finds that for every control point, there are a slight of discrepancies occurred. As shown in figure below (Figure 4.2) which takes example at Control Point 1. The yellow point is where the base GPS is located (Control Point 1) at the field area, however, when the actual coordinates gained by the GPS instruments at Control Point 1 is keyed into Google Earth, it shows the exact actual location is at the white point. Thus, this clearly shows that there are discrepancies occurred that maybe due to stretching of image. (Refer Appendix for Other Control Points Discrepancies Image)


Figure 4.2. Discrepancies shown at CP 1

Table below shows the Root Mean Square (RMS) for each control points developed by ER Mapper Software. The RMS is developed by the software from the Easting and Northing coordinate keyed in with the cell X and cell Y which is the coordinate of the control point on the software. Based on the software, the pixel size is 2.64 meters (after resampling the product of image rectification process), thus the RMS should lower than 2.64 meters in order to proceed to next step. The RMS is later used to produce a rectified image of the map.

Table 4.5. RMS of each control points developed from software.

| Name | Cell X | Cell Y | Easting | Northing | RMS |
|---|---|---|---|---|---|
| 1 | 371.66 | 516.27 | 718132.95380 | 484584.38317 | 0.60 |
| 2 | 439.07 | 687.98 | 718276.49909 | 484235.92415 | 0.45 |
| 3 | 166.06 | 595.27 | 717710.02371 | 484425.38174 | 0.55 |
| 4 | 194.61 | 403.78 | 717764.18838 | 484812.64686 | 0.37 |
| 5 | 717.18 | 222.71 | 718850.57632 | 485190.87757 | 0.68 |
| 6 | 667.82 | 416.22 | 718750.71942 | 484787.66596 | 0.74 |
| 7 | 575.67 | 264.77 | 718554.98524 | 485099.20801 | 0.72 |
| 8 | 454.22 | 279.99 | 718300.65934 | 485067.56337 | 0.68 |
| 9 | 426.50 | 119.05 | 718241.03774 | 485401.98627 | 0.25 |
| 10 | 215.06 | 231.43 | 717804.82235 | 485164.50135 | 0.65 |
| 11 | 525.61 | 127.00 | 718447.78439 | 485386.36876 | 0.28 |
| 12 | 818.82 | 162.89 | 719062.18239 | 485317.16823 | 0.63 |
| 13 | 858.43 | 245.16 | 719146.66843 | 485143.53446 | 0.32 |
| 14 | 915.98 | 189.61 | 719267.09581 | 485262.06438 | 0.70 |
| 15 | 831.58 | 495.91 | 719091.91956 | 484624.32093 | 0.33 |
| 16 | 1096.09 | 177.88 | 719644.39825 | 485285.80063 | 0.71 |
| 17 | 1088.61 | 285.79 | 719629.47014 | 485059.65573 | 0.35 |
| 18 | 1116.33 | 384.65 | 719687.93221 | 484853.76545 | 0.42 |
| 19 | 1046.31 | 476.18 | 719542.82679 | 484664.51522 | 0.37 |
| 20 | 962.37 | 467.90 | 719366.81502 | 484682.89801 | 0.67 |

Figure below shows image of UTP campus map that has been rectified by the software. Study noticed that the image has been re-oriented and truncate back as the image before it was uploaded into Google Earth. This image will give improve accuracy on coordinates around the study area.


Figure 4.3. Rectified map based on the RMS produced by the software

Noted that there are shrinkage on the left side, upper left and lower left of the map (Figure 4.3). This rectification (shrinkage) is done by the ER Mapper Software based on the RMS developed. As mentioned before, the RMS is developed by the differences from the software coordinates and the coordinates (gained from survey work) entered into the software.

### 4.3 Digital Mapping Based on Rectified Google Earth Image

As an additional work, based on the rectified UTP map, digital mapping can be done by extracting layers such as vegetation, road, buildings (cafeteria, residential, academic) and hill & forest. This digital mapping is developed using the ARCView GIS Software. The significance of this that it will differentiate on which is buildings, water body, roads and vegetation on the study area of this research. (Refer Figure 4.4)


Figure 4.4. Digital Mapping Based on Rectified Map

**4.4 Discussion**

For all the 20 control points as stated in table above, there are slight differences between the geospatial data which is coordinates obtained by the field work with the coordinates from the Google Earth. Upon the result, it is noted that before rectification, the image is stretch towards Easting as most of the control points are having discrepancies towards Easting.

Based on the result of 'Table 4.4.-Differences in Latitude, Longitude and meters', the average, minimum and maximum discrepancies/offsets in meter are listed as below :

Table 4.6 Summary of Offset Distance

| Offset | Distance (m) |
|---|---|
| Minimum (Point 15) | 0.77 |
| Average | 7.058 |
| Maximum (Point 9) | 12.57 |

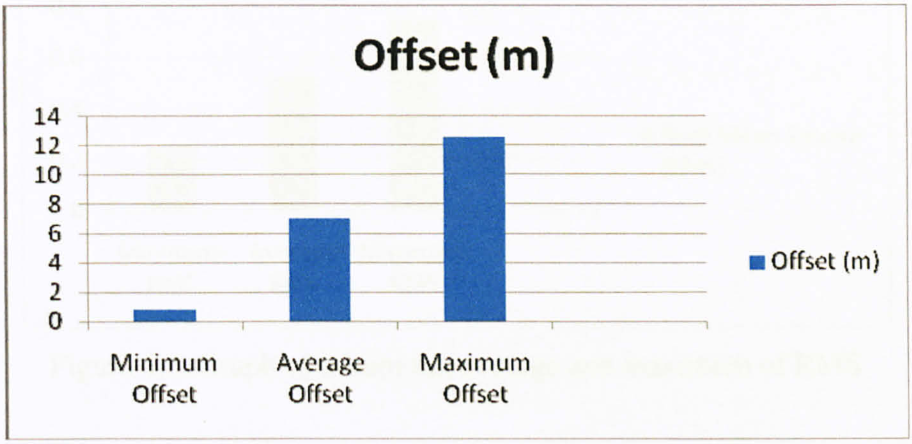


Figure 4.5. Graph of minimum, average and maximum offset

From Table 4.6 and Figure 4.5, this defines that Control Point 9 contains the maximum offset among other control points which is 12.57 m while Control Point 12 contains the minimum offset which is 0.77 m. The average offset of all the Control Points is 7.058 m.

Based on the result of 'Table 4.5.-RMS of each control points developed from software', the average, minimum and maximum RMS are listed as below :

Table 4.7 Summary of RMS

| RMS | RMS |
|---|---|
| Minimum (Point 9) | 0.25 |
| Average | 0.5235 |
| Maximum (Point 6) | 0.74 |

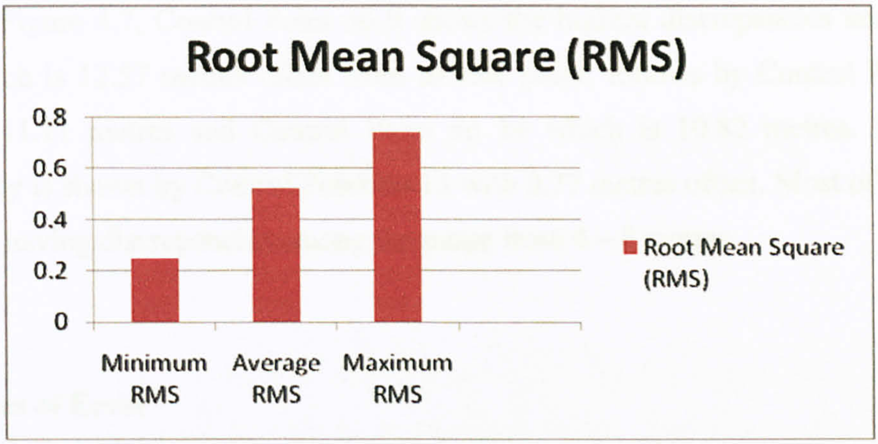


Figure 4.6. Graph of minimum, average and maximum of RMS

From Table 4.7 and Figure 4.6, this defines that Control Point 6 contains the maximum RMS among other control points which is 0.74 m while Control Point 9 contains the minimum RMS which is 0.25 m. The average offset of all the Control Points is 0.5235 m.

Figure below summarize the discrepancies/offsets and RMS value for all the control points for the field study.

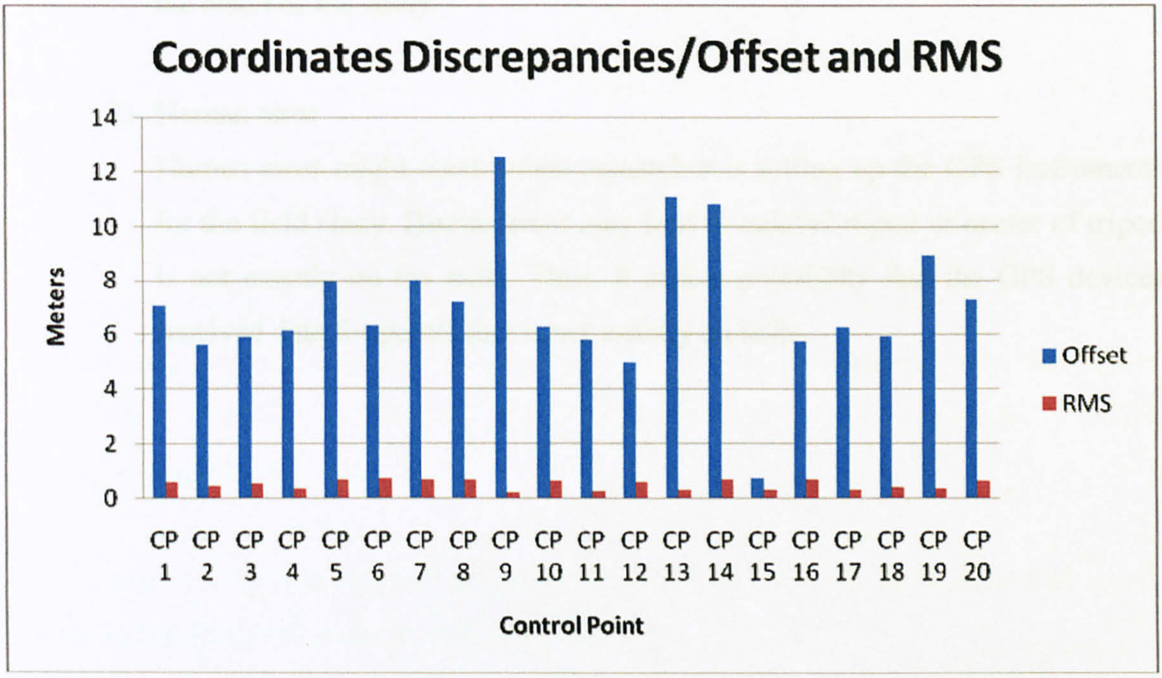


Figure 4.7. Coordinates Discrepancies/Offets and RMS for all control points

From the Figure 4.7, Control Point no 9 shows the highest discrepancies and values of offset which is 12.57 metres offset from its real point, follows by Control Point no 13 which is 11.11 metres and Control Point no 14 which is 10.82 metres. The lowest discrepancy is shown by Control Point no 15 with 0.77 metres offset. Most of the control points are having discrepancies among the range from 4 – 8 metres.

**4.5 Sources of Error**

In conducting this study, there were possibly contributing errors found which are :

1) Parallax error

   This error is due to parallax error (eyesight error) when choosing the pin point from the Google Earth map. When user pin point the cursor on the control point in the Google Earth map, it has the possibility that it is not accurately on the dot of the control point. This kind of error will slightly change and affect the result of the study.

2) Human error

   Human error might occur when researcher is setting up the GPS instruments for the field study. Human error may lead to unlevel tripod or center of tripod is not exactly on the nails. Thus, it makes possibility that the GPS devices received data for points that is not exactly on nails.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

Accurate Mappings are essential in order to provide a precise location at exact place or location. As taking the Google Earth as the Open Source Freeware application and the coordinates as the geospatial data, this research has been able to prove that the coordinates obtained from the Google Earth contains discrepancies which may be due to stretching the imagery map to fit the globe. A solution should be reach in order to rectify the error and discrepancies.

From this research study, it can be concluded that a rectified and improve coordinates of UTP campus map has been developed and from the study also determined the quantity differences between the geospatial data. Thus, objective is achieved.

This research study provides a dynamic solution for an accurate of UTP campus map using the software mentioned. The challenge in this report is to rectify all the coordinates by analyzing the plane. As end result, the ER Mapper software will develop a rectified image of UTP campus based on the Root Mean Square. In this map, the map will be re-oriented and truncate as to its original map before uploaded into Google Earth. From this rectified map, it will increase the accuracy of coordinates compared to the map before rectification where the coordinates of the image have been stretch or expand to fit the globe of Google Earth.

It is hoped that by this findings will give benefits to all levels of professional levels related to this field and to the societies as well.

### 5.2 Recommendation

There are several recommendations to increase the accuracy of the result. In order to get and increase accurateness, it is suggested that :

- More control points to be set up randomly distributed as the more control points will produce higher accuracy result.
- Pin point of cursor at Google Earth software and ER Mapper software is done few times and take the average of the reading to prevent and reduce the parallax error.
- For all the control points, make sure that the instruments set up is level and exactly on the point that has been chosen.

## REFERENCES

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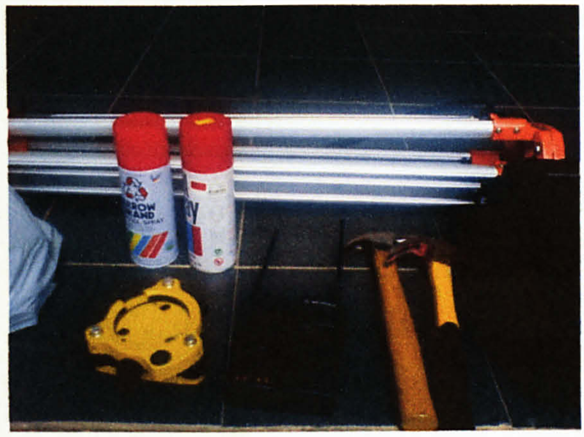
# APPENDICES

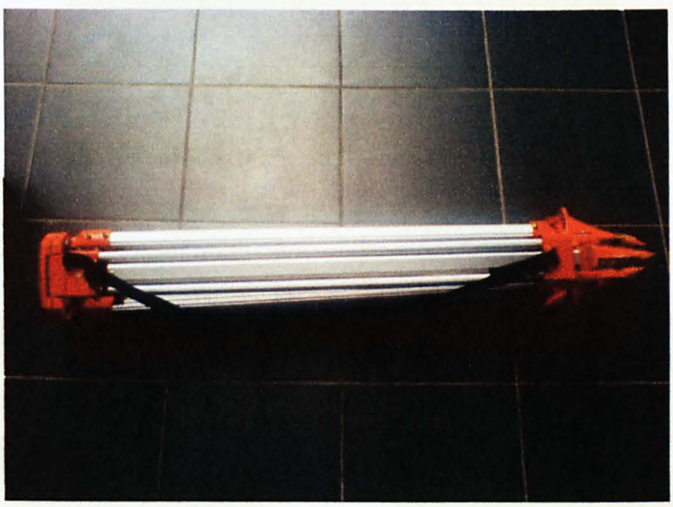
# Appendix A

## Tools

Appendix 1 : GPS Topcon Set



Appendix 2 : Sets of Instruments



Appendix 3 : Tripod

Control Points For Study

Appendix 4 : Base Control Point

Appendix 5 : Control Point 6

Appendix 6 : Control Point 7

Appendix 7 : Control Point 13

Appendix 8 : Control Point 12

Appendix 9 : Control Point 16

Appendix 10 : Control Point 19

Appendix 11 : Control Point 18

Appendix 12 : Control Point 20

Appendix 13 : Control Point 10

Appendix 14 : Control Point 11

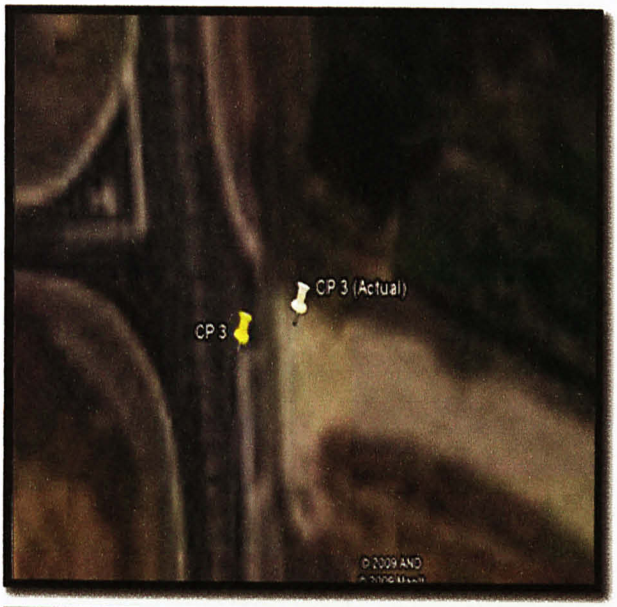
Appendix 15 : Author Setting up Control Point

# Appendix B: Discrepancies



Control Point 1

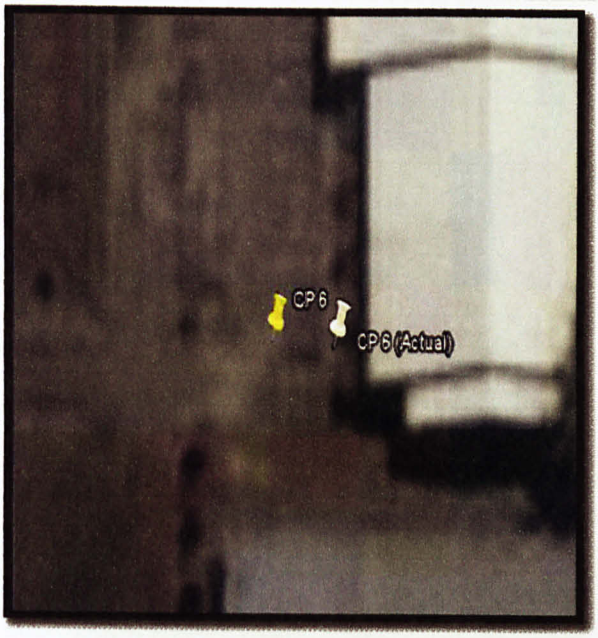
Control Point 2





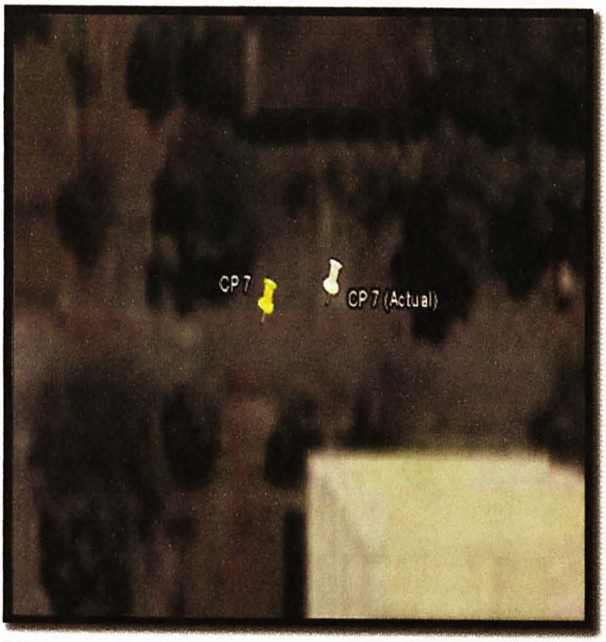
Control Point 3

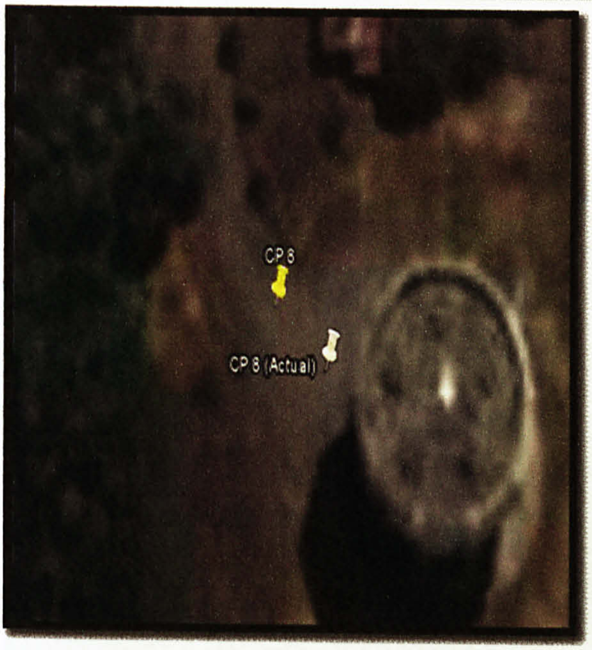
Control Point 4


Control Point 5

Control Point 6



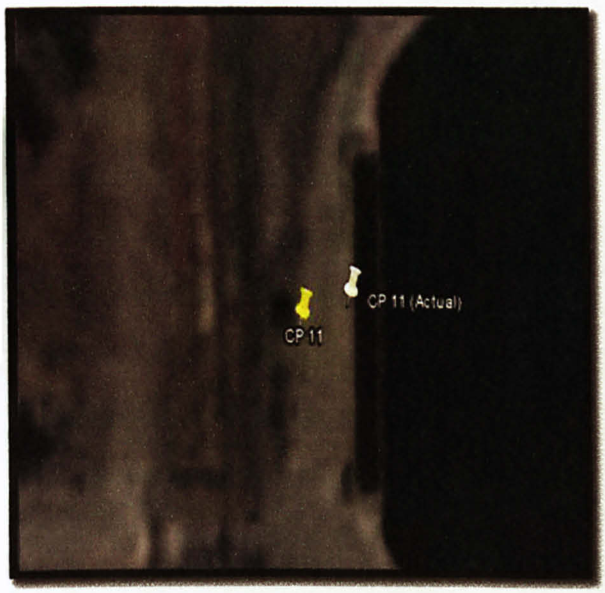




Control Point 7

Control Point 8

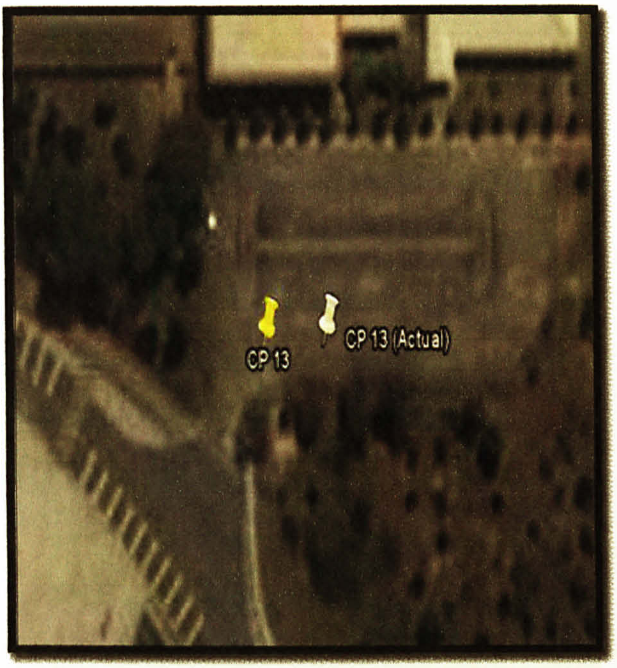

Control Point 9


Control Point 10

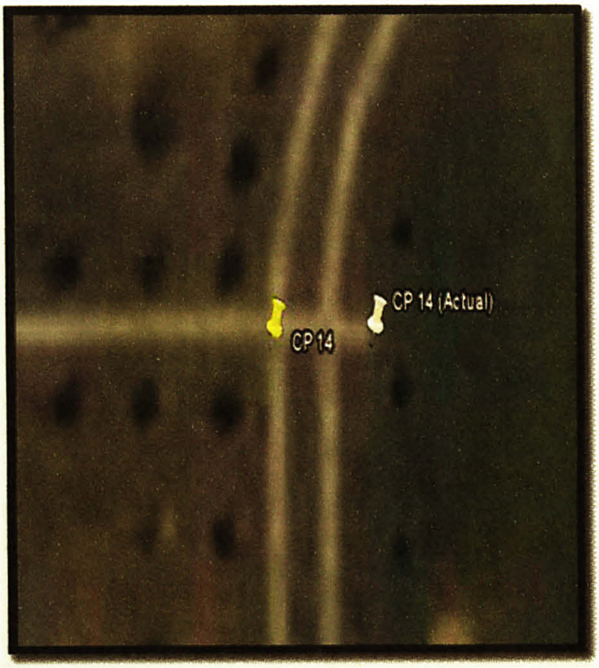



Control Point 11


Control Point 12




Control Point 13



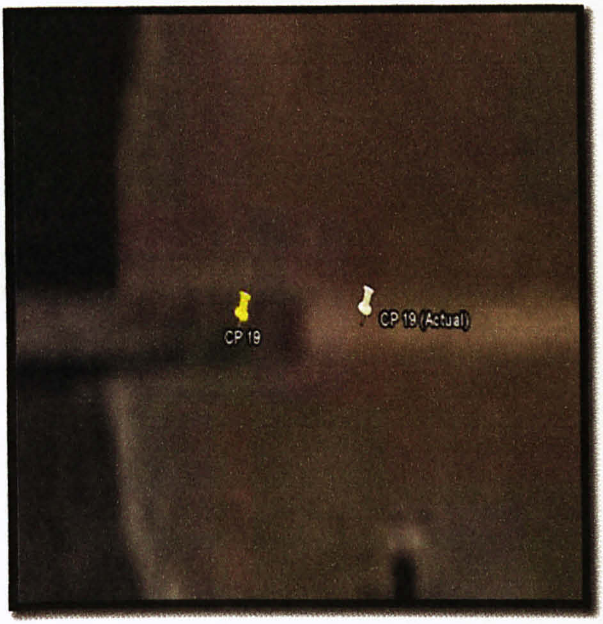

Control Point 14


Control Point 15

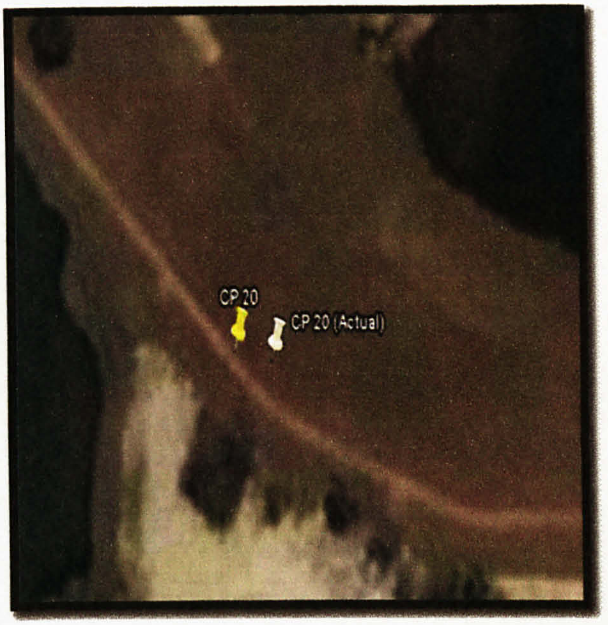

Control Point 16


Control Point 17


Control Point 18




Control Point 19




Control Point 20

# APPENDIX C :
# SAMPLE TEST STUDY

# APPENDIX D :

# TUDY MAP OF UTP CAMPUS WITH LOCATIONS OF ALL CONTROL POINTS

# APPENDIX D :

# STUDY MAP OF UTP CAMPUS WITH LOCATIONS OF ALL CONTROL POINTS


CP 1 (Base Point)
CP 2
CP 3
CP 4
CP 5
CP 6
CP 7
CP 8
CP 9
CP 10
CP 11
CP 12
CP 13
CP 14
CP 15
CP 16
CP 17
CP 18
CP 19
CP 20
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© 2009 Tele Atlas
Image © 2009 DigitalGlobe
©2008

# APPENDIX E :

# SATELLITE NETWORK LAYOUT OF CONTROL POINTS


CP 9
CP 11
CP 12
CP 16
CP 14
CP 5
CP 10
CP 7
CP 13
CP 8
CP 17
CP 18
CP 6
CP 4
CP 20
CP 15
CP 19
(Base Point)
CP 3
CP 2
© 2009 Google
© 2009 MapIt
© 2009 Tele Atlas
©2008

# APPENDIX F :
# RECTIFIED MAP


CP 9
CP 11
CP 12
CP 16
CP 14
CP 10
CP 5
CP 13
CP 7
CP 8
CP 17
CP 18
CP 4
CP 6
CP 20
CP 15
CP 19
CP 1 (Base Point)
CP 3
CP 2
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